



## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification <sup>6</sup> : <b>G01N 33/68, 33/566 // C07K 16/18, 14/47</b>		A2	(11) International Publication Number: <b>WO 98/35236</b>
			(43) International Publication Date: 13 August 1998 (13.08.98)
(21) International Application Number: PCT/IE98/00007 (22) International Filing Date: 6 February 1998 (06.02.98) (30) Priority Data: S970081                  6 February 1997 (06.02.97)                  IE S970228                  24 March 1997 (24.03.97)                  IE S970325                  1 May 1997 (01.05.97)                  IE (71) Applicant (for all designated States except US): ENFER TECHNOLOGY LIMITED [IE/IE]; Block A, Earlsfort Centre, Earlsfort Terrace, Dublin 2 (IE). (72) Inventor; and (75) Inventor/Applicant (for US only): O'CONNOR, Michael [IE/IE]; 13 Chestnut Grove, Mount Merrion, County Dublin (IE). (74) Agents: GATES, Marie, Christina, Esther et al.; Tomkins & Co., 5 Dartmouth Road, Dublin 6 (IE).		(81) Designated States: AL, AM, AT, AT (Utility model), AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, CZ (Utility model), DE, DE (Utility model), DK, DK (Utility model), EE, EE (Utility model), ES, FI, FI (Utility model), GB, GE, GH, GM, GW, HU, ID, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SK (Utility model), SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).  <b>Published</b> <i>Without international search report and to be republished upon receipt of that report.</i>	
(54) Title: IMMUNOLOGICAL ASSAY FOR SPONGIFORM ENCEPHALOPATHIES			
(57) Abstract			
<p>The invention relates to a method of detecting Transmissible Spongiform Encephalopathies (TSE) in animals, particularly in animal carcasses, using an anti-PrP<sup>Sc</sup> antibody in an immunological assay. Also disclosed is a diagnostic kit for detecting TSE comprising the same antibody.</p>			

*FOR THE PURPOSES OF INFORMATION ONLY*

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	ES	Spain	LS	Lesotho	SI	Slovenia
AM	Armenia	FI	Finland	LT	Lithuania	SK	Slovakia
AT	Austria	FR	France	LU	Luxembourg	SN	Senegal
AU	Australia	GA	Gabon	LV	Latvia	SZ	Swaziland
AZ	Azerbaijan	GB	United Kingdom	MC	Monaco	TD	Chad
BA	Bosnia and Herzegovina	GE	Georgia	MD	Republic of Moldova	TG	Togo
BB	Barbados	GH	Ghana	MG	Madagascar	TJ	Tajikistan
BE	Belgium	GN	Guinea	MK	The former Yugoslav Republic of Macedonia	TM	Turkmenistan
BF	Burkina Faso	GR	Greece	ML	Mali	TR	Turkey
BG	Bulgaria	HU	Hungary	MN	Mongolia	TT	Trinidad and Tobago
BJ	Benin	IE	Ireland	MR	Mauritania	UA	Ukraine
BR	Brazil	IL	Israel	MW	Malawi	UG	Uganda
BY	Belarus	IS	Iceland	MX	Mexico	US	United States of America
CA	Canada	IT	Italy	NE	Niger	UZ	Uzbekistan
CF	Central African Republic	JP	Japan	NL	Netherlands	VN	Viet Nam
CG	Congo	KE	Kenya	NO	Norway	YU	Yugoslavia
CH	Switzerland	KG	Kyrgyzstan	NZ	New Zealand	ZW	Zimbabwe
CI	Côte d'Ivoire	KP	Democratic People's Republic of Korea	PL	Poland		
CM	Cameroon	KR	Republic of Korea	PT	Portugal		
CN	China	KZ	Kazakstan	RO	Romania		
CU	Cuba	LC	Saint Lucia	RU	Russian Federation		
CZ	Czech Republic	LI	Liechtenstein	SD	Sudan		
DE	Germany	LK	Sri Lanka	SE	Sweden		
DK	Denmark	LR	Liberia	SG	Singapore		
EE	Estonia						

Immunological assay for Spongiform Encephalopathies

The present invention relates to method of detecting Transmissible Spongiform Encephalopathies and to an immunological assay or test for  
5 Transmissible Spongiform Encephalopathies (TSE).

Background to the invention

Spongiform Encephalopathies are a group of degenerative  
10 neurological diseases. There are a number of examples of Spongiform Encephalopathies including BSE (Bovine Spongiform Encephalopathy), Scrapie, Creutzfeldt-Jakob Disease (CJD), Gerstmann-Straussler-Scheinker Syndrome, Kuru, Transmissible Mink Encephalopathy, Chronic Wasting Disease of Mule Deer, Feline Spongiform Encephalopathies and  
15 other Spongiform Encephalopathies found in animals such as elk, nyala, greater kudu, gemsbok and tigers. It has also been reported that BSE can be transmitted under laboratory conditions to mice and pigs. This crossing of species barriers by the infective agent has led to increased concern that transfer to humans could occur.

20

Bovine Spongiform Encephalopathy (BSE) is a degenerative brain disorder of cattle which is popularly known as "mad cow disease". It has a slow incubation period, up to four or five years with symptoms of progressive degeneration of the mental state in cows include loss of  
25 coordination and staggering gait, lack of interest in their surroundings, disinterest in feed and water, or unpredictable behaviour, including aggressiveness. Affected cattle show symptoms when they are three to ten years old.

30

First identified in Great Britain in November 1986, over 100,000 cases have since been recorded there. Post mortems of affected cattle reveal a characteristic pattern of vacuolation in the brain tissue due to destruction of neural cells and the deposition of unusual protein fibres, that give the brain a spongy (spongiform) texture. Similar  
35 spongiform diseases have been recognized in humans (for example, Creutzfeldt-Jakob disease or CJD) for over a century and in sheep (scrapie) for over 200 years. The agent thought to be responsible for BSE and its counterparts is an infective protein known as a prion. The prion is an infective particle comprising protein only and no nucleic

- 2 -

acid, the presence of nucleic acid being required in the case of a conventional virus. In Scrapie in particular one protein known as prion protein or PrP<sup>SC</sup>, has been found to co-purify with infectivity and can produce a Scrapie-like condition in brain cell cultures from  
5 other animals, such as hamsters under laboratory conditions. PrP<sup>SC</sup> is the only known component of the characteristic protein fibres deposited in the brain tissue of Scrapie-infected sheep. This protein, the PrP<sup>SC</sup> appears to undergo a structural modification, whereas the term PrP<sup>C</sup> is used in respect of the normal cellular counterpart of  
10 PrP<sup>SC</sup>. The natural function of PrP<sup>C</sup> is not known, but it appears likely that it has an essential structure or functional role in the organism.

Recycled animal tissue, which had been routinely fed to British  
15 dairy cows as a protein supplement has been identified as the source of the infection. It is believed that BSE was originally spread from sheep's brains infected with scrapie and that its spread was accidentally accelerated by the ingestion of brain tissue taken from cows that had become infected with BSE. Therefore, the British  
20 Government introduced compulsory destruction of suspect animals and their carcasses beginning in 1988. The feeding of animal tissue to cows was banned in Britain in July 1988.

Since the initial report of the disease, consumers have feared  
25 that it might be transferable to humans through milk or beef products, particularly since Kuru, a related disease is known to be spread by ritualistic cannibalism among New Guinea tribesmen. In late 1990, consumer concern over the transmission of BSE to humans triggered a collapse in the beef market. A similar scare struck Germany in  
30 mid-1994.

In 1996 ten cases of a newly described type of fatal CJD (Variant CJD) were identified. The victims had distinct brain tissue symptoms, were all under the age of 42, and had no hereditary record of the  
35 disease. It has been suggested that the victims may have contracted the disease through contact with BSE-infected cattle before the eradication of suspected animals had taken effect. The identification of Variant CJD led to a dramatic drop in beef consumption in Britain, and the banning of British and in some instances Irish beef imports in

- 3 -

various countries worldwide.

Therefore, for both veterinary and economic reasons, there is an urgent need to provide a method for diagnosis and a diagnostic kit to  
5 detect infection with BSE, Scrapie and other related Spongiform Encephalopathies, in livestock, animal carcasses and meat generally.

#### Object of the invention

10 It is therefore an object of the present invention to provide a method of testing cattle, particularly animal carcasses, for the infective agent responsible for BSE. It is also an object that protection method be rapid, with the result being available in a matter of hours, that it should be cheap, reliable and user-friendly.

15 Such a detection method would have the advantage that it would prevent the entry of infected meat into the human food chain, thus eliminating the possibility of humans contracting Variant CJD or other related diseases which may be transmitted by eating infected meat. It  
20 has the further advantage that it would restore consumer confidence in meat and meat products, which would be advantageous for both the farming community and the meat industry in general.

At present there is no test available which can identify infected  
25 meat carcasses or livestock carcasses, and there is no product available which can allay public fears regarding meat consumption.

The current invention provides an immunological assay for the putative agent PrP<sup>SC</sup> the rogue prion protein believed to be  
30 responsible for Spongiform Encephalopathies.

#### Summary of the invention

According to the present invention there is provided a method for  
35 detecting the putative agent for TSE in animals comprising taking a body tissue sample from an animal, reacting the sample in a immunological assay with a labelled antibody which is capable of reacting with PrP<sup>SC</sup> and determining the amount of labelled antibody bound to the sample.

- 4 -

Suitably, the antibody used in the assay is raised against a synthetic peptide sequence having the general formula:

X-(R<sub>1</sub>-Lys-His-R<sub>2</sub>)-Ala-Gly-Ala-Ala-Ala-R<sub>3</sub>-Gly-Ala-Val-Val-Gly-G  
 5 ly-Leu-Gly-Gly-Tyr-Met-Leu-Gly-Ser-Ala-Met-Ser-(Arg-Pro-R<sub>4</sub>-R<sub>5</sub>)-Y

wherein R<sub>1</sub> is an amino acid residue selected from Met, Leu and Phe;

R<sub>2</sub> is either Met or Val;

R<sub>3</sub> is Ala or is absent;

10 R<sub>4</sub> and R<sub>5</sub> are independently an amino acid residue selected from Leu, Ile and Met; one or more residues within brackets maybe present or absent with the proviso that if they are present they are attached to the rest of the peptide in sequence; and X and Y may each independently be absent or independently be one or more additional  
 15 amino acid residues.

Particularly preferred are prion specific antibodies raised against one or more of the following sequences:

20 MVKSHIGSWILVLFVAMWSDVGLCKKRPKPGGGWNTGGSRYPGQ-44  
GSPGGNRYPPGGGGWGQPHGGGWGQPHGGGWGQPHGGGGQGP-87  
GGGGWGQGGSHSQWNKPSKPKTNMKHVAGAAAGAVVGGGLGGY-131  
 MLGSAMSSPLIHFGNDYEDRYTRENMYRYPNQVYYRPVDRYSNQNN-177

25 More particularly preferred are antibodies raised against the underlined sequences shown above.

The antibody used in the assay is preferably a C5 antibody to PrP<sup>SC</sup> which is available from Proteus, England, called herein the  
 30 differentiation reagent. Other anti-PrP<sup>SC</sup> antibodies are also suitable for use in the invention. Suitable antibodies are those directed against the synthetic peptides disclosed in WO 93/11155.

The immunological assay may be a competitive assay in which a  
 35 solid support, suitably a microtitre plate, is pre-coated with a carrier protein-peptide conjugate, the animal tissue sample and an anti-peptide antibody are added to the solid support, allowed to react and the support washed. a labelled anti-(anti-peptide antibody) antibody is added, allowed to react, washed, a signal reagent added and

- 5 -

the signal read. The label may be horseradish peroxidase.

The primary antibody used in the assay is preferably a rabbit anti-PrP<sup>SC</sup> antibody and the secondary antibody is preferably  
5 selected from a goat, sheep, donkey or other anti-rabbit antibody.

In a particular embodiment an ELISA assay can be used to identify the peptide fragment for PrP<sup>SC</sup>, but other suitable immunological assays could be used.

10

In a preferred embodiment an enhanced chemiluminescence assay is used to aid in detection of the PrP<sup>SC</sup> agent. The animals may suitably be cattle, sheep and pigs and the tissue sample may suitably be taken from a carcass of such animals.

15

The steps involved are:

1. Clean up of nervous tissue to allow detection of putative agent for PrP<sup>SC</sup> (the rogue prion protein believed responsible for  
20 Spongiform Encephalopathies);
2. Assay priming step involving addition of specific agents (antibodies);
- 25 3. ELISA using wells pre-coated with peptide fragment for PrP<sup>SC</sup>;
4. Enhanced chemiluminescence assay for detection of PrP<sup>SC</sup> agent; and
- 30 5. Determination of results.

In particular the assay involves assay for the PrP<sup>SC</sup> protein which is the infective prion protein found in BSE. The assay is capable of distinguishing between PrP<sup>SC</sup> and PrP<sup>SC</sup> which is the  
35 normal BSE prion protein. The PrP<sup>SC</sup> protein is a series of peptides in a triple helix whereas in PrP<sup>SC</sup> one third of the molecule is in the form of a flat beta-sheet.

It is particularly important that the assay can discriminate

- 6 -

between natural PrP<sup>C</sup> and PrP<sup>SC</sup>, since PrP<sup>C</sup> is found in normal subjects while both PrP<sup>C</sup> and PrP<sup>SC</sup> are found in diseased subjects.

5 In a particularly preferred embodiment, a sample of CNS tissue, suitably a cross-section of spinal cord, is removed from an animal carcass, homogenised, filtered and plated onto a microtitre tray. The sample is then reacted in an immunological assay with an antibody as described above.

10 The invention also provides a test kit for the detection of TSE in animals comprising an anti-peptide antibody as defined above.

The method allows the rapid detection of a TSE agent in a carcass, with results being available in a matter of hours, usually about one  
15 and a half to two hours. Thus the carcass can be removed from the abattoir before passing into the human food chain.

#### Detailed description of the invention

20 The invention will now be described in greater detail with reference to the Examples.

The requirements for the Enfer TSE immunoassay are as follows:

- 25 a) A sample of CNS tissue  
b) A series of preparative sample treatments  
c) A prion specific antibody  
d) Sensitive method of detection
- 30 a) A sample of CNS tissue is removed from a beef carcass at the point of slaughter using a specialised sampling clavical (available from Medisteel, Dublin, Ireland). This tissue sample must be such that a cross-section of spinal cord can be removed from the sample for confirmatory analysis if necessary. The sample is placed in a  
35 universal container and is identified with a traceable identification number i.e. an EU 4 digit carcass number, an Irish Department of Agriculture ear-tag number or a traceable factory kill number. The sample is transported to the laboratory for testing.



- 7 -

- b) On reaching the laboratory the sample is identified using barcodes. The barcode assigned to each sample incorporates information on the factory of origin of the sample, the date the animal is killed and a traceable identification sample number. An amount of each sample, ranging in weight from 0.3g to 1.1g, is removed and placed into a stomacher bag for homogenisation. This bag containing a section of the original sample will be assigned an identical barcode to the original sample. This allows full traceability throughout the system. A fixed volume of Homogenising Buffer is added to the stomacher bag and the sample homogenised. The sample is then dispensed in duplicate onto a prepared 96 well microtitre plate. A fixed volume of Differential Buffer is applied to the microtitre plate and incubated. A fixed volume of Priming Buffer is then added to the samples on the plate and incubated. This step completes the sample preparation procedure.
- c) The samples are now ready for immunoassay. This requires a prion specific antibody. This antibody is raised in rabbits to a synthetic prion peptide. A fixed volume of this specific antibody is added to the microtitre plate, incubated and washed. A fixed volume of secondary antibody is added to the plate, incubated and washed. Detection of results is now possible.
- d) Detection of results is by means of Enhanced Chemiluminescence. A fixed volume of a chemiluminescence reagent is added to the microtitre plate and incubated. The light signal is read using a Labsystems Chemiluminometer, the results assigned to the corresponding barcode and a results report printed.

### Example 1

#### REAGENTS

#### REAGENTS FOR HOMOGENISATION OF SAMPLES

- Enfer Homogenisation Buffer (HB)  
Reverse Osmosis Water  
Differentiation Reagent  
Positive Control

- 8 -

## Negative Control

Enfer Immunoassay Priming Buffer (IPB)

## REAGENTS FOR THE IMMUNOASSAY PROCEDURE

5

1.5 M Phosphate Buffered Saline (PBS)

150mM Phosphate Buffered Saline (PBS)/Tween 20 (0.05%)

Sodium Chloride Solution (NaCl)

Rabbit Anti-PrP peptide in 150 mM PBS/Tween 20 (0.05%) diluted as

10 instructed by the supplier

Normal Goat Serum

Donkey Anti-Rabbit IgG-Horse Radish Peroxidase conjugate in 150mM

PBS/Tween 20 (0.05%) diluted as instructed by the supplier

Amerlite Reagent<sup>™</sup> Johnson & Johnson Clinical diagnostics

15

## EQUIPMENT

Bar-code reader and computer database interface

Bar-code label printer

20 Rotating (bottle) mixer

96 well microtitration plate chemiluminescence reader

96 well microtitration plate shaking incubator (2)

96 well microtitration plate washer (2)

Micro-computer

25 Laser Printer

Micro-computer 'custom' software - data processing and reporting

Deep Freeze Storage -20°C

Refrigerated Storage 4°C

30 Reverse Osmosis Water System

Automated 8 channel pipettes

Automated microtitre plate strip dispenser

Vortex Mixer

Disposable Pasteur pipettes

35 Stomacher homogeniser and bags (variable quantity)

Blades

Secure sample boxes and transport trailers

Class II Safety Cabinet system

Autoclave

- 9 -

SAMPLES AND SAMPLING PROCEDURE

The sample shall be such as to enable the detection of PrP<sup>SC</sup> protein in spinal chord.

- 5 The size of the sample will be sufficient to permit the primary analysis and if necessary, a repeat or confirmatory analysis to be carried out.

Samples will be taken in a manner which will ensure that a fixed amount of tissue will be taken for each sample.

- 10 Samples will be taken in a manner which will permit identification of the sample in the laboratory.

The method of packaging, preservation and transport to the laboratory will maintain the integrity of the sample such that the results of the analysis is not prejudiced.

- 15 Samples for analysis will be transported to the laboratory, in insulated and sealed containers.

PROCEDURE

20 HOMOGENISATION AND PREPARATION OF TISSUE

7.5 ml Homogenisation Buffer (HB) is added to each sample.

The sample is sealed and placed in the homogeniser, homogenise for 3 minutes.

- 25 Remove the sample from the homogeniser and after accumulation of 40 samples, place the samples onto a designated rack.

Apply 0.02ml differentiation reagent to each well of the pre-coated microtitre plate except wells A1,A2.

- 30 Transfer, in order, the identification bar-code of each sample to the microcomputer with a bar-code scanner.

Apply 0.18ml of sample to each well except A1, A2, A3, A4 (controls).

Cover the plate with a microtitre plate sealer.

Incubate the microtitre plate for 1 hour at 37°C, shaking.

Wash the microtitre plate wells 8x with 0.4ml NaCl solution.

- 35 Dispense 0.25ml of the Immunoassay Priming Buffer to each well.

Incubate the microtitre plate for 15 minutes at 37°C, shaking.

Wash the microtitre plate wells 4x with 0.4ml PBS/Tween 20 (0.05%) solution.

- 10 -

## CHEMILUMINESCENT IMMUNOASSAY

Dispense 0.2ml primary antibody into each well of the microtitration plate.

- 5 Incubate the microtitration plate for 40 minutes, with shaking, at 37°C.

Wash the microtitration plate wells 4x with 0.4ml of PBS/Tween 20 (0.05%) solution.

- 10 Dispense 0.2ml secondary antibody into each well of the microtitration plate.

Incubate the microtitration plate for 30 minutes, with shaking, at 37°C.

Wash the microtitration plate wells 4x with 0.4ml of PBS/Tween (0.05%) solution.

- 15 Dispense 0.15ml Amerlite™ reagent into each well of the microtitration plate.

Incubate the microtitration plate for 3 minutes, with shaking, at 37°C.

Read the luminescence in the reader.

- 20 Data reduction and interpretation.

## CALCULATION OF RESULTS

N/A

25

ANTIBODIES, HOMOGENISATION BUFFER, IMMUNOASSAY  
PRIMING BUFFER, QUALITY CONTROLS

## ANTIBODIES

30

\* rabbit Anti-PrP peptide, stored frozen and diluted to working strength as instructed by the supplier.

\* donkey Anti-Rabbit IgG-Horse Radish Peroxidase (HRP) conjugate, stored at 4°C, to be diluted as instructed by the supplier.

- 35 \* normal goat serum, stored at 4°C, to be diluted as appropriate.

- 11 -

## QUALITY CONTROLS

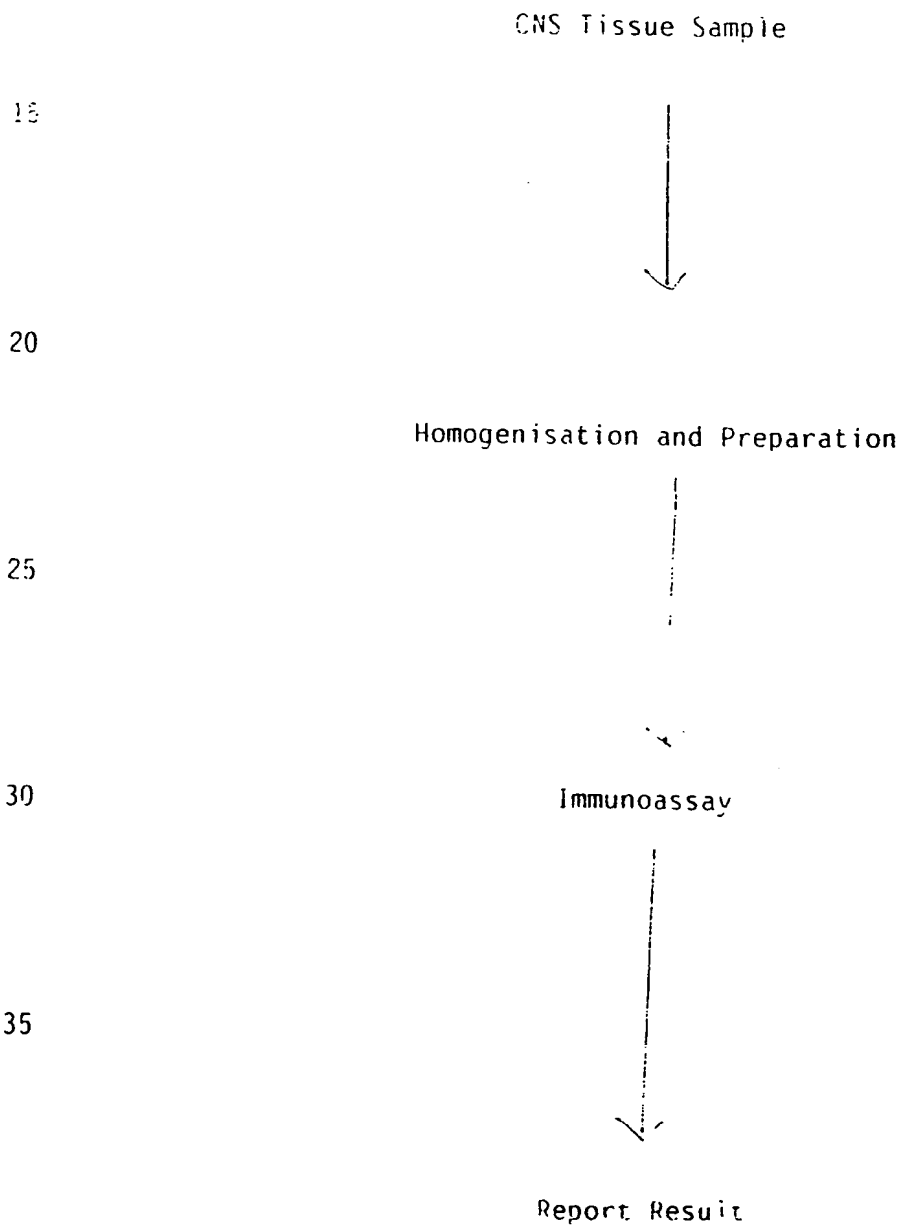
Supplied by Veterinary Research Laboratories, Abbotstown, Dublin.

## 5 SOURCE OF ALL REAGENTS

Enfer Scientific Ltd.,  
Co. Tipperary,  
Ireland.

10

## FLOW DIAGRAM



- 12 -

## Example 2

### 1. Homogenisation:

- 5 1.1 1g of CNS tissue is removed from the sample and placed in a stomacher bag.
- 1.2 15ml of Homogenising Buffer is added to the section.
- 10 1.3 This mixture is homogenised for 3 minutes using a stomacher homogeniser.
- 1.4 The resultant homogenate is filtered through a 1 micron filter.

### 15 2. Plating:

- 2.1 96-well microtite plate is prepared by dispensing 200 ul of Adhering Agent into each well and incubating overnight at 37°C.
- 20 2.2 Wash the plate 4XPBST (5 x Phosphate Buffered Saline tablets, supplied by Sigma, U.K., to 1 litre reverse osmosis H<sub>2</sub>O/1% Tween 20) (150mM) before use.
- 2.3 200ul of blank control (such as water, saline solution or buffer)  
25 is dispensed in duplicate onto the plate, positions A1,2.
- 2.4 200ul of negative control (known negative BSE homogenate) is dispensed - 4 replicates - onto the plate, positions B1,2 C1,2. The known negative BSE homogenate is supplied by the Veterinary  
30 Research Laboratory, Abbotstown, Castlknock, Dublin, Ireland.
- 2.5 200ul of positive control (known positive BSE homogenate, available from the Veterinary Research Laboratory, Abbotstown, Castlknock, Dublin, Ireland) is dispensed - 4 replicates - onto  
35 the plate, positions D1,2 E1,2.
- 2.6 200ul of each filtered homogenate is dispensed in duplicate onto the plate, remaining positions.

- 13 -

2.7 50ul of Differential Buffer is dispensed onto the plate bringing the well volume to 250ul.

2.8 The plate is covered with a microtitre plate sealer and incubated at 20°C for 30 minutes.

2.9 The plate is centrifuged for 30 minutes at 2000rpm.

2.10 The plate is then washed 4 times with 150mM PBST.

2.11 50ul of Priming Buffer are added to each well of the microtitre plate and the plate incubated for 1 hour at 37°C.

2.12 The plate is washed 4 times with 150mM PBST.

### 3. Immunoassay:

3.1 250ul of primary prion specific antibody, a rabbit anti-Prion peptide antibody at a dilution of 1:2000, is dispensed onto the plate.

3.2 The plate is incubated at room temperature for 40 minutes.

3.3 The plate is washed 4 times with 150mM PBST.

3.4 250ul of secondary antibody, a donkey-anti-rabbit HRP at a dilution of 1:2000 is dispensed onto the plate and the plate incubated at 37°C for 30 minutes.

3.5 The plate is washed 4 times with 150mM PBST.

### 4. Detection:

4.1 250ul of Enhanced Chemiluminescent reagent (amerlite reagent, supplied by Johnson & Johnson Clinical Diagnostics, U.K.) is added to the plate.

4.2 The plate is incubated at room temperature for 10 minutes.

- 14 -

- 4.3 The light signal is read using a Labsystems Chemiluminometer (supplied by Medical Supply Co., Dublin, Ireland), which is a scanning wavelength reader. The device reads the luminescence from each well of the plate by scanning the entire IR-visible-UV spectra and extrapolating results.
- 4.4 The light signals from the plate are transferred to a customised software package (available from G.K.S. Software, Dublin, Ireland).
- 4.5 Each light signal is assigned to a corresponding barcode and a report printed.
- 4.6 Results are quoted in chemiluminescent light unit L.U.

#### 15 SOURCE OF REAGENTS

1. Plate Adhering Agent, Homogenising Buffer, Priming Buffer and Differential Buffer are supplied by Enfer Products Ltd.
2. Prion Specific Antibodies - anti-PrP - are supplied by Enfer Products and are rabbit antibodies raised to the following synthetic prion peptides.
- PRION SEQUENCE
- N-TERMINAL
- 25 MVKSHIGSWILVLFVVMWSDVGLCKKRPKPGGGWNTGGSRYPGO-44  
GSPGGNRYPPQGGGGWGQPHGGGWGQPHGGGWGQPHGGGQGP-87  
GGGGWGQGGSHSQWNKPSKPPKTNMKHVAGAAAGAVVGGGLGGY-131  
MLGSAMSSPLIHFGNDYEDRYTRENMYRYPNQVYYRPVDRYSNQNN-177
- 30 All the sequences used herein are given using standard I.U.P.A.C. three letter code abbreviations for amino acid residues to find as follows:
- 35 A - Alanine, C - Cysteine, D - Aspartic acid, E - Glutamic acid,  
F - Phenylalanine, G - Glycine, H - Histidine, I - Isoleucine,  
K - Lysine, L - Leucine, M - Methionine, N - Asparagine, P - Proline,  
Q - Glutamine, R - Arginine, S - Serine, T - Threonine, V - Valine,  
W - Tryptophan and Y - Tyrosine.



- 15 -

Both underlined sequences, (a 34 amino-acid peptide and a 40 amino acid peptide) are used to raise rabbit anti-PrP antibodies. The peptides are conjugated to activated ovalbumin and injected intra-muscularly in Freund's Complete Adjuvant. Booster injections are sub-cutaneous and  
5 Freund's Incomplete Adjuvant is used. The rabbits are bled at 30 days.

3. Chemiluminescent reagent is supplied by Johnson and Johnson, Clinical Diagnostics, U.K. and results are read using a Labsystems Chemiluminometer.

10

### Example 3

### VALIDATION DATA

#### 15 1. INTER-ASSAY VARIATION

Data generated on a positive control and a negative control, in a total of 10 assays are provided in Table 1. These controls have been deemed positive and negative by two unrelated methods - histology (HIS)  
20 and immunohistochemistry (ICC), methods which will ultimately be used to confirm results reported using the Enfer test. The inter-assay variations based on these two samples are 19% for the positive control and 93% for the negative control. These data indicate that the assay has acceptable reproducibility. Another control was also included in  
25 this study. This was a peptide control which allows study of the variation between assays due to antibody differences from day to day. These data are included in Table 1. Again the inter-assay variation at 14% is satisfactory.

#### 30 2. INTRA-ASSAY VARIATION

The intra-assay variation was determined using the same type controls as those used for the inter-assay study (positive, negative and peptide) and placing 23 replicates of each control on a single  
35 plate. Data generated on these controls are provided in Table 2 showing 9% variation for the positive control, 11% for the peptide control and 57% for the negative control.

- 16 -

### 3. STABILITY STUDIES

A number of stability studies were carried out for the purpose of this validation:

5

#### (a) HOMOGENATE STABILITY

In this case a sample was homogenised and divided into aliquots. Over a seven day period, the same homogenate was tested on four occasions using aliquots stored at  $-20^{\circ}\text{C}$ ,  $2-8^{\circ}\text{C}$ , and on two occasions using aliquots stored at room temperature and  $37^{\circ}\text{C}$ . The results, outlined in Table 3, show that the light signal is stable, allowing for inter-assay variation, over this period with storage conditions of  $-20^{\circ}\text{C}$ , with some deterioration at  $2-8^{\circ}\text{C}$ , room temperature and  $37^{\circ}\text{C}$ .

10  
15

#### (b) STABILITY OF HOMOGENISING BUFFER (HB)

This study was set up to determine the expiry date of homogenising buffer for production purposes. A similar protocol to that outlined in (a) above was followed with the results provided in Table 4. Again the results show that the HB is stable for use.

20

#### (c) STABILITY OF PRIMARY ANTIBODY - WORKING STRENGTH

25

Undiluted antibody can be stored frozen for an indefinite length of time. However antibody diluted to working strength using PBS/Tween 20 (0.05%) is not as stable as concentrated antibody and a stability study was therefore carried out. Antibody dilutions of 1:1K were made on 9 occasions over a 72 day period. On the final day of the study, each of the 9 preparations was applied to an antigen coated plate and an ELISA carried out. The results are presented in Table 5 and from these data it can be seen that the working strength antibody is stable for at least a 70 day period.

30

35

#### (d) STABILITY OF SAMPLE IN HOMOGENISING BUFFER BEFORE HOMOGENISATION

This stability test was carried out to ensure that the assay would

- 17 -

not be affected if some factor resulted in a delay in homogenising the sample after the HB had been added. Homogenising buffer was added to a sample in the ratio of 1g of brain to 15ml of buffer and the mixture left at room temperature overnight (15 hours). The sample was  
5 homogenised after this time and an immunoassay carried out. The results are shown in Table 6 (- 2 samples tested one without and one with a delay). The treatment made no difference to the eventual result.

10

15

20

25

30

35

**Table 1 :** *Inter-assay variation data, generated on a single positive and negative control sample, in 10 assays.*

Assay Number	Blank	'Neg' Control	'Pos' Control	Peptide Control
1	2	4	30834	110524
day 1				
2	2	13	33789	105242
day 1				
3	2	12	35319	104293
day 1				
4	15	23	32533	101227
day 2				
5	13	15	35424	114084
day 2				
6	17	15	31749	124122
day 3				
7	28	50	22732	146110
day 3				
8	7	13	29143	114355
day 4				
9	18	22	28565	111084
day 4				
10	13	12	36213	100920
day 4				

\* The value stated at each data point is the mean value of replicates of each control in the assays. The overall mean stated below is calculated using every individual replicate value. The values are quoted in chemiluminescence light units - LU.

Blank	'Neg' Control	'Pos' Control	Peptide Control
Mean = 11	Mean = 16	Mean = 31927	Mean = 111691
SD = 10	SD = 15	SD = 5954	SD = 15331
CV = <u>91%</u>	CV = <u>93%</u>	CV = <u>19%</u>	CV = <u>14%</u>
n = 46	n = 51	n = 51	n = 42

**Table 2 :** *Intra-assay variation data, generated on a single positive and negative control sample, 23 replicates of each on a single plate.*

Replicate Number	Blank	'Neg' Control	'Pos' Control	Peptide Control
1	34	69	19857	96632
2	49	34	17738	95999
3	22	39	18354	112017
4	29	87	19645	121987
5	38	33	18975	119077
6	51	149	19828	118386
7	34	32	16466	103699
8	38	40	18259	106592
9	24	16	19840	119148
10	32	155	22813	101386
11	26	20	23004	88538
12	17	84	22153	99612
13	57	46	21880	99803
14	32	28	21722	92699
15	25	30	21069	117642
16	57	137	18524	82359
17	18	41	19644	88442
18	45	46	22478	97731
19	15	162	21596	92286
20	20	34	22438	115472
21	13	21	21661	118239
22	33	21	20113	97596
23	19	13	20007	93713

\* The values are quoted in chemiluminescence light units - LU

Blank	'Neg' Control	'Pos' Control	Peptide Control
Mean = 32	Mean = 72	Mean = 20351	Mean = 104742
SD = 13	SD = 41	SD = 1753	SD = 11601
CV = <u>41%</u>	CV = <u>57%</u>	CV = <u>9.0%</u>	CV = <u>11%</u>
n = 23	n = 23	n = 23	n = 23

**Table 3:** *Homogenate Stability Study - mean of 3 replicates at each temperature***POSITIVE CONTROL**

Day	-20°C	2-8°C	RT	37°C
0			1550	
2	1073	449	664	205
3	1162	413	-	-
5	2025	887	-	-
7	1661	1198	709	472
30				
90				
180				

**NEGATIVE CONTROL**

Day	-20°C	2-8°C	RT	37°C
0			39	
2	10	15	6	6
3	9	12	-	-
5	17	37	-	-
7	20	31	10	11
30				
90				
180				

\* The value at each data point is represented by 3 replicates.

**Table 4 :** *Homogenising Buffer Stability Study - mean of 3 replicates at each temperature*

**POSITIVE CONTROL**

Day	-20°C	2-8°C	RT	37°C
0			24719	
2	53526	61248	42873	47088
3	-	31593	24762	-
7	32420	34457	36337	35010
30				
60				
180				

**NEGATIVE CONTROL**

Day	-20°C	2-8°C	RT	37°C
0			37	
2	4	6	3	4
3	-	9	9	-
7	14	16	20	14
30				
60				
180				

The value at each data point is represented by 3 replicates.

**Table 5 :** *Primary Antibody Stability Study*

Day	I°Antibody Mean Light Signal	SD - 8 Replicates	% CV
1	19849	557	2.8
3	17677	77	0.4
4	21796	340	1.6
9	18283	218	1.2
23	16805	282	1.7
25	21285	377	1.8
30	21059	427	2.0
42	18339	353	1.9
72	17774	511	2.9

**Table 6 :** *Study of sample stability in HB for a 15 hour period before homogenising*

Sample I.D.	Hours before homogenisation	Mean Result (LU)
79	0	73233
POS	15	72578
80	0	18
NEG	15	38

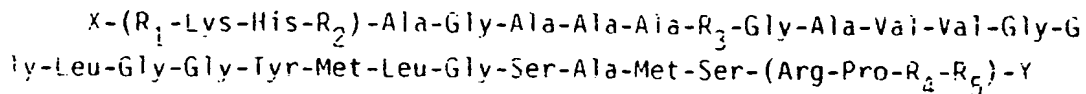
\* The mean values stated represent 4 replicates at each data point.



- 23 -

CLAIMS

1. A method for detecting the putative agent for TSE in animals comprising taking a body tissue sample from an animal, reacting the sample in a immunological assay with a labelled antibody which is capable of reacting with PrP<sup>SC</sup> and determining the amount of labelled antibody bound to the sample.
2. A method as claimed in claim 1 wherein the antibody used in the assay is raised against a synthetic peptide sequence having the general formula:



15

wherein  $R_1$  is an amino acid residue selected from Met, Leu and Phe;

$R_2$  is either Met or Val;

$R_3$  is Ala or is absent;

$R_4$  and  $R_5$  are independently an amino acid residue selected from Leu, Ile and Met; one or more residues within brackets maybe present or absent with the proviso that if they are present they are attached to the rest of the peptide in sequence; and X and Y may each independently be absent or independently be one or more additional amino acid residues.

25

3. A method as claimed in any preceding claim wherein the antibodies are prion specific antibodies raised against one or more of the following sequences:

30 MVKSHIGSWILVLFVAMWSDVGLCKKRPKPGGGWNTGGSRYPGQ-44

GSPGGNRYPPQGGGGWGQPHGGGWGQPHGGGWGQPHGGGQGP-87

GGGGWGQGGSHSQWNKPSKPPKTNMKHVAGAAAGAVVGGGLGGY-131

MLGSAMSSPLIHFGNDYEDRYTRENMYRYPNQVYYRPVDRYSNQNN-177

4. A method as claimed in claim 3 wherein the antibodies are antibodies raised against the underlined sequences shown in claim 3.

35

- 24 -

5. A method as claimed in any preceding claim wherein the immunological assay may be a competitive assay in which a solid support, suitably a microtitre plate, is pre-coated with a carrier protein-peptide conjugate, the animal tissue sample and an anti-peptide antibody are added to the solid support, allowed to react and the support washed, a labelled anti-(anti-peptide antibody) antibody is added, allowed to react, washed, a signal reagent added and the signal read.
6. The method as claimed in any preceding claim wherein the animals are selected from cattle, sheep and pigs and the tissue sample is taken from a carcass of such animals.
7. A method as claimed in any preceding claim wherein a sample of CNS tissue, suitably a cross-section of spinal cord, is used for testing.
8. A test kit for the detection of TSE in animals comprising an anti-peptide antibody raised against a synthetic peptide sequence having the general formula:
- $$X-(R_1\text{-Lys-His-}R_2\text{)-Ala-Gly-Ala-Ala-Ala-}R_3\text{-Gly-Ala-Val-Val-Gly-Gly-Leu-Gly-Gly-Tyr-Met-Leu-Gly-Ser-Ala-Met-Ser-(Arg-Pro-}R_4\text{-}R_5\text{)-Y}$$
- wherein  $R_1$  is an amino acid residue selected from Met, Leu and Phe;  
 $R_2$  is either Met or Val;  
 $R_3$  is Ala or is absent;  
 $R_4$  and  $R_5$  are independently an amino acid residue selected from Leu, Ile and Met; one or more residues within brackets maybe present or absent with the proviso that if they are present they are attached to the rest of the peptide in sequence; and X and Y may each independently be absent or independently be one or more additional amino acid residues.

35



## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

<b>(51) International Patent Classification <sup>6</sup> :</b> <b>G01N 33/68, 33/566 // C07K 16/18, 14/47</b>	<b>A3</b>	<b>(11) International Publication Number:</b> <b>WO 98/35236</b> <b>(43) International Publication Date:</b> 13 August 1998 (13.08.98)
<b>(21) International Application Number:</b> PCT/IE98/00007 <b>(22) International Filing Date:</b> 6 February 1998 (06.02.98)  <b>(30) Priority Data:</b> S970081                      6 February 1997 (06.02.97)                      IE S970228                      24 March 1997 (24.03.97)                      IE S970325                      1 May 1997 (01.05.97)                      IE  <b>(71) Applicant (for all designated States except US):</b> ENFER TECHNOLOGY LIMITED [IE/IE]; Block A, Earlsfort Centre, Earlsfort Terrace, Dublin 2 (IE).  <b>(72) Inventor; and</b> <b>(75) Inventor/Applicant (for US only):</b> O'CONNOR, Michael [IE/IE]; 13 Chestnut Grove, Mount Merrion, County Dublin (IE).  <b>(74) Agents:</b> GATES, Marie, Christina, Esther et al.; Tomkins & Co., 5 Dartmouth Road, Dublin 6 (IE).		<b>(81) Designated States:</b> AL, AM, AT, AT (Utility model), AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, CZ (Utility model), DE, DE (Utility model), DK, DK (Utility model), EE, EE (Utility model), ES, FI, FI (Utility model), GB, GE, GH, GM, GW, HU, ID, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SK (Utility model), SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).  <b>Published</b> <i>With international search report.</i> <i>Before the expiration of the time limit for amending the claims</i> <i>and to be republished in the event of the receipt of amendments.</i>  <b>(88) Date of publication of the international search report:</b> 10 December 1998 (10.12.98)
<b>(54) Title:</b> IMMUNOLOGICAL ASSAY FOR SPONGIFORM ENCEPHALOPATHIES  <b>(57) Abstract</b>  The invention relates to a method of detecting Transmissible Spongiform Encephalopathies (TSE) in animals, particularly in animal carcasses, using an anti-PrP <sup>SC</sup> antibody in an immunological assay. Also disclosed is a diagnostic kit for detecting TSE comprising the same antibody.		

**FOR THE PURPOSES OF INFORMATION ONLY**

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	ES	Spain	LS	Lesotho	SI	Slovenia
AM	Armenia	FI	Finland	LT	Lithuania	SK	Slovakia
AT	Austria	FR	France	LU	Luxembourg	SN	Senegal
AU	Australia	GA	Gabon	LV	Latvia	SZ	Swaziland
AZ	Azerbaijan	GB	United Kingdom	MC	Monaco	TD	Chad
BA	Bosnia and Herzegovina	GE	Georgia	MD	Republic of Moldova	TG	Togo
BB	Barbados	GH	Ghana	MG	Madagascar	TJ	Tajikistan
BE	Belgium	GN	Guinea	MK	The former Yugoslav Republic of Macedonia	TM	Turkmenistan
BF	Burkina Faso	GR	Greece	ML	Mali	TR	Turkey
BG	Bulgaria	HU	Hungary	MN	Mongolia	TT	Trinidad and Tobago
BJ	Benin	IE	Ireland	MR	Mauritania	UA	Ukraine
BR	Brazil	IL	Israel	MW	Malawi	UG	Uganda
BY	Belarus	IS	Iceland	MX	Mexico	US	United States of America
CA	Canada	IT	Italy	NE	Niger	UZ	Uzbekistan
CF	Central African Republic	JP	Japan	NL	Netherlands	VN	Viet Nam
CG	Congo	KE	Kenya	NO	Norway	YU	Yugoslavia
CH	Switzerland	KG	Kyrgyzstan	NZ	New Zealand	ZW	Zimbabwe
CI	Côte d'Ivoire	KP	Democratic People's Republic of Korea	PL	Poland		
CM	Cameroon	KR	Republic of Korea	PT	Portugal		
CN	China	KZ	Kazakstan	RO	Romania		
CU	Cuba	LC	Saint Lucia	RU	Russian Federation		
CZ	Czech Republic	LI	Liechtenstein	SD	Sudan		
DE	Germany	LK	Sri Lanka	SE	Sweden		
DK	Denmark	LR	Liberia	SG	Singapore		
EE	Estonia						

## INTERNATIONAL SEARCH REPORT

International Application No

PCT/IE 98/00007

## A. CLASSIFICATION OF SUBJECT MATTER

IPC 6 G01N33/68 G01N33/566 //C07K16/18,C07K14/47

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 6 C07K G01N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 93 11155 A (PROTEUS MOLECULAR DESIGN LTD.) 10 June 1993 see the whole document	1-8
X	US 4 806 627 A (WISNIEWSKI ET AL.) 21 February 1989 see the whole document	1,7
P,X	WO 97 37227 A (INSTITUUT VOOR DIERHOUDERIJ EN DIERGEZONDHEID) 9 October 1997 see the whole document	1,6,7
P,X	WO 97 10505 A (THE REGENTS OF THE UNIVERSITY OF CALIFORNIA) 20 March 1997 see examples see claims	1,6,7

☐ Further documents are listed in the continuation of box C.

Patent family members are listed in annex.

## ° Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&amp;" document member of the same patent family

Date of the actual completion of the international search

22 October 1998

Date of mailing of the international search report

29/10/1998

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2  
NL - 2280 HV Rijswijk  
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,  
Fax: (+31-70) 340-3016

Authorized officer

Nooij, F

# INTERNATIONAL SEARCH REPORT

Information on patent family members

Patent Application No

PCT/IE 98/00007

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
WO 9311155	A	10-06-1993	AU 675053 B	23-01-1997
			AU 3089292 A	28-06-1993
			CA 2124953 A	10-06-1993
			EP 0616613 A	28-09-1994
			JP 7501798 T	23-02-1995
			NZ 246059 A	28-08-1995
			US 5773572 A	30-06-1998
			ZA 9209392 A	27-07-1993
<hr/>				
US 4806627	A	21-02-1989	NONE	
<hr/>				
WO 9737227	A	09-10-1997	AU 2180897 A	22-10-1997
<hr/>				
WO 9710505	A	20-03-1997	AU 7073596 A	01-04-1997
			EP 0852011 A	08-07-1998
<hr/>				